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FUTURE REVENUE OF THE ERIE CANAL.

"We are advocates that great works of national utility should originate with the people; we are inimical, in the highest degree, to legislative interference with anything, from the making of a steam-engine to that of the smallest article; we conceive it is the duty of a wise and a paternal Government to aid and assist public companies in their exertions and endeavors to execute works of public utility: but, on the other hand, if a Government once assumes the mantle of general manufacturer of steam-engines, engineer-general of railroads, &c., under an act of the legislature, then the rights and interests of all the industrious classes are directly invaded, a monopoly set up, and the spirit of enterprise, of invention, and improvement ceases, and all those vigorous trading impulses which have so eminently contributed to the wealth and to the prosperity of all free and enlightened countries."

"'Legislation is not health but human welfare:' and the Government of Great Britain has quite enough to do in legislation for this great empire and the colonies thereunto belonging, without interfereing with projects which should be left entirely to the enterprise of the people under proper legislative restrictions for the good of the public."—*Civ. En. Jour.*

The success of the Erie Canal will be immediately brought forward to show that the above spirited remarks do not apply to this country, all allusion to the failure of the other canals of this State, of Pennsylvania, Ohio, Maryland, etc., being carefully avoided. We will, therefore, examine the causes which have enabled the Erie Canal to pay the ordinary expenses, with interest on cost of construction, as well as the probability of its continuing to do so.

In the first place they were projected by individual sagacity, and it was only by the greatest exertions that they were undertaken by the Government, the question agitating the whole state and forming the test at the polls precisely in the same manner as with the New York and Erie Railroad in the southern counties for the last two years. All the other Canals which have been undertaken by the State *since* the completion of the Erie Canal have, it is true, received the sanction of the legislature, but the people of the State generally did not know, and only too large a majority do not now know that they have incurred a debt of four and a half millions for Canals of which they heard nothing until they were informed that the first appropriations were expended, and that owing to changes in the work from 50 to 200 per cent. additional on the original estimate was required. The Erie and Champlain Canals had, however, other advantages. "If the Erie and

Champlain Canals had been deprived of the benefit of the auxiliary funds, which were originally pledged for the payment of the money borrowed, there would have been a debt against these Canals on the 30th September, 1838, after deducting the surplus of the present year, of $8,459,069. And in this estimate the Erie Canal has all the benefit of the contributions to it in consequence of the construction of the lateral Canals."

"The original cost of the Erie and Champlain Canals, that is, the sum actually expended in constructing them, was $8,401,394 12. Thus it is shown, that in the operation of borrowing, expending and reimbursing the cost of the Erie and Champlain Canals, *confining these works to their own resources*, the *debt* at the end of 21 years would be $57,675 greater than the *whole sum originally expended* in constructing the Canals."

"An estimate made out on the same principle as the one before alluded to, in regard to the finished lateral Canals, shows that without the aid of the treasury or auxiliary resources the Oswego, Cayuga and Seneca, Chemung, Crooked Lake and Chenango Canals, would have been indebted on the 30th Sept., 1838, to the amount of $4,949,182. Add estimated debt of Erie and Champlain Canals as given above, $8,459,069, and it makes a total of $13,408,201."

"This embraces all the finished Canals, 650 miles in extent, and shows the result of the operations of the whole system for twenty-one years, *excluding from the estimate the aid derived from auxiliary funds.* The difference between $13,408,201 and the actual state of all the Canal debts at the close of the fiscal year is $9,851,362, and this is the amount in money and the interest thereon which has been contributed in various ways from the *common fund* of the State to the Canal fund. This is a debt which the Canals owe to the whole people of the State, and which debt the Comptroller, in his report in 1834, proposed to have settled in an *equitable* manner. If this debt had been *adjusted* when the Canals were finished instead of *being used to give a delusive prosperity to them*, it would have furnished a fund which might have been apportioned among the counties and used for roads and other improvements in those sections of the State not adapted to Canals and Railroads, or applied to expenditures of a general character and in which every tax payer has an interest."—[Assem. Doc. No. 4, pp. 27 and 28, Comptroller's Report, 1839.]

We have here a fair account of the manner in which the "delusive statements" of the success of the Erie Canal were got up. If contributions "in various ways from the common fund of the State" had been placed to the credit of the Chenango that hopeful Canal would have paid for itself by this time, though even after that, its income would not equal the amount of ordinary expenses, repairs, and renewals. The case is widely different with the Erie Canal. Having been paid for in a great measure by general taxes on the people of the State, it now yields a large revenue, indeed it has an income sufficient to pay all its expenses with interest on cost of construction, besides appropriating such sums as would in a very few years repay

the original cost. Thus, if the entire nett revenue of the Erie Canal had been applied to liquidating the debt incurred for its construction it would have all been paid off by the end of the year 1850, if we suppose $800,000 per annum to be appropriated to that object; but by that time the debts of the *lateral Canals* would amount to $7,000,000, exclusive of the costs and deficiencies of the Genessee and Black River Canals. Were there no obstacles in the way a considerable increase of tolls would be certain, and under favorable circumstances the nett annual revenue ten years hence might reach or perhaps exceed a million of dollars.

The extreme uncertainty attending any estimate of the future income of the Erie Canal will be very easily demonstrated. The gross income of 1838 was (Sen. Doc. No. 27, 1339,) $1,414,174, towards which "merchandize and passengers" contributed $530,788, or nearly two-fifths of the gross income; a sum considerably *exceeding* the nett revenue of all the Canals for 1838, which was $491,888 (Assem. Doc. No. 4, p. 59,) and not much less than the estimated nett revenue for 1839, $620,000. Now unless the present law restraining the Utica and Schenectady Railroad from carrying freight can be kept in force the Erie Canal must inevitably lose the transportation of merchandize—practically speaking, its entire surplus.

The Empire State as yet does not condescend to enter into competition with her subjects; the farmer is not allowed to send his produce to market except over her highway; the mechanic and the poor man in the cities must render tribute to speculators and capitalists if the thermometer should sink a few degrees lower than usual in November, and thus cut off the supply of the staff of life for the winter; the merchant is forced to send his goods to the West by the way of Philadelphia if expected to reach their destination before summer; and the country merchants and inhabitants generally of the western part of this State are not allowed to receive their supplies by any other *practicable* route. This stupendous monopoly, founded "jure divino," may or may not exist till the Erie Canal pays for itself, but the total abolition of this "peculiar institution" of the State of New-York is eventually certain as the climate of this continent is not favorable to the "divine right." It is not difficult to point out the effects of complete emancipation. Commencing in the spring, the country merchants of this State will have their goods on their shelves, and the western traders will have their merchandize on the shores of Lake Erie by the time the Erie Canal opens, for the present rates of transportation on merchandize will pay well on a Railroad. But the present high rates paid on merchandize enable the forwarder to bring down flour at a very low rate, and if he loses the former he will be under the necessity of greatly advancing the rates on the latter; besides which as the Railroad companies must necessarily be prepared to carry a large quantity of *up* freight they can well afford to bring *down* the flour nearly or quite as low as it can be carried by the Canal. Again, during the winter flour would be carried to Boston

by the Western Railroad and to New York by the Albany Railroad on the slightest advance in value in those cities, and prices would be equalized to a degree attainable by no other means. The Canal, however, would no longer be used for the transportation of that article; the tolls on which amounted in 1838 to $277,063

Tolls on merchandize, ...	516,686
Passengers, ...	14,102
And we have a grand total of	$807,851

This sum exceeds by 20 per cent. the estimated nett surplus of 1839, which has been already stated to be $620,000, and even slightly exceeds the nett revenue of all the Canals estimated for 1839 ($800,000), supposing the deficiencies of the lateral Canals to be paid by direct taxation.

To show that this estimate is rather under than over what may be expected, the amount of $166,120 has been omitted, though the articles on which it is paid are sufficiently valuable to pay good rates of transportation, and will therefore be commanded by a Railway. They are as follows:

Fur and Peltry, $1,695; Pork, 10,291; Beef, 1,029; Cheese, 4,756; Butter and Lard, 5,773; Wool, 2,132; Wheat, 67,705; Rye, 166; Corn, 2,651; Barley, 19,792; other Grain, 4,521; Cotton, 1,846; Tobacco, 1,067; Clover and Grass Seed, 2,588; Flax Seed, 514; Hops, 270; Domestic Spirits, 7,093; Leather, 708; Furniture, 14,447; Salt, 17,076.—Total, $166,120.

Those who feel disposed to examine more in detail the ground on which the future revenue of the Erie Canal is based will find all the requisite data in the last Reports of the Comptroller and of the Commissioners of the Canal Fund for 1838, and the more thorough their investigation the stronger will be their conviction that the present income of the Erie Canal can only be continued by the stern and unyielding exercise of the might of the State over the right of the citizen. The yoke, however, will not gall much till the completion of the line of Railroads from Albany to Buffalo, very soon after which the exclusive right of the Erie Canal to carry freight will cease to exist. We have all looked with contempt and pity on the revenue and debt of the Government works of Pennsylvania for the last few years, but the day may not be far off which will see the State of New York in a still less enviable situation, from which nothing can save her but the entire abandonment of the system of constructing, under the specious term of "auxiliary Canals," works which never can be required and which never can pay their expenses. This most extraordinary policy is one of the two distinguishing characteristics of the administration of this State for the last eighteen years, and it would appear impossible to conceive any stronger argument against Canals projected and executed by agents of the Government. In Pennsylvania they are already earnestly discussing the project of confining the Government to its legitimate sphere of action, and its consequent withdrawal from

the business of forwarding, dealing in foreign and domestic exchange, constructing Railways, advancing on cotton, building or repairing locomotive or other engines, etc., and judging from the noble stand lately taken by the present spirited and patriotic governor, there is every reason to believe that he will consider no sacrifice too great which may be the means of putting down for ever the vast monopolies of that State, which have eventually proved as injurious to the revenue of the Government as they have been withering in their influence on private enterprise.

It is said that we are here on the eve of a change, and the public works of this State are in that happy condition when a change must be attended with advantages. Still we have no confidence in *any* system of internal improvements under the control of the Government, and have great hopes that the brilliant success which has attended the public works of Massachusetts, all projected, constructed, and managed by private companies, will carry conviction to the minds of all, that individual energy and enterprise are, when untrammelled by the baneful interference of Government, as active in New as in Old England. And why should not the following eloquent remarks apply to the Anglo-Saxon race on this as well as on the other side of the Atlantic?

"Will not the Government of this country read a letter of wisdom from past events? Has not steam navigation across the Atlantic Ocean been achieved in the most satisfactory manner by private enterprise? Have not the river navigations, and also the whole of the canals of England, been executed by companies? Are not all the steam-vessels which cover, not only the British seas, but also those of Europe, entirely due to the successful enterprise of companies? And have not the noblest engineering works in the world been accomplished by private companies? Look at the bridges of Waterloo and Southwark; they will prove that the people are quite capable of executing works as stupenduous and monumental as the pyramids of Egypt, but of a much more useful and noble kind. We are thoroughly convinced that wherever works of a public nature have been executed by the Government, they have not only been inferior to those now named, but they have also been attended with much more expense than if undertaken by private enterprise."

"Looking at France, oue of the most powerful nations of Europe, and where by arbitrary authority the public works of that country had been placed under the control of the State; are those works, we ask, more substantially executed, or kept in a better state of repair than those of Great Britain? Is it not allowed by every person who has travelled through England and Erance, that the roads of the former country are much better than those of the latter, and that the superiority in the velocity of travelling in Great Britain is well known and admitted to surpass that of any other country. It is also remarkable that our bridges, harbours, canals, aye and also our railways, are, we venture to say with pride, the most substantially executed, and the grandest works of the kind that the people of any nation in the world has yet executed. These noble engineering works astonish all travellers who have visited Great Britain; they announce the genius and enterprise of not only a great, but that of a free people, whose unparalleled activity and intelligence have not been fettered and withered by legislative enactments in the promotion of commerce, the increase of our national wealth, and the consequent greatness of this empire: and this may be justly attributed to perfect freedom being allowed to every kind of private enterprise under parliamentary regulation."—*Civ. Eng. Jour.*

The following vigorous and sensible article, though evidently written in great haste, contains so many excellent remarks that we lay it before our readers with an earnest recommendation to their attention. Of the superiority of railroads as a means of communication, we had conceived that there was no doubt, but legislative documents and frequent remarks in the public prints induce us to believe that the old and ill founded prejudices in favor of Canals (so ably discussed and refuted in the annexed communication) are yet entertained by many who should know better. The facts of the case are determined beyond dispute, and we hesitate not, to challenge

the refutation of the argument derived therefrom. We refrain from further comment, for we are detaining our readers from the article itself.

RAILROADS *destined to supercede canals, in the transportation of merchandize and produce to and from the seaboard to the valley of the Mississippi and the St. Lawrence.*

Railroads, and their capacity to transport merchandize, manufactures and agricultural products of every description, with their importance to the Union, *as a means of defence*, has not been presented in the several relations the subject merits.

In England, France and Holland, as well as in the United States, the first efforts towards internal improvements were directed to canals. France succeeded with her Languedock canal. The Duke of Bridgewater took the lead in England, with the canal which bears his name, whilst Holland with numerous canals, became intersected in every direction; the State of New York, in the face of opposing councils, accomplished the construction of the Erie canal, which has given her the name of Empire State to the Union.

The successful canal policy of this State, was followed by Pennsylvania, Maryland, and Virginia, in their desire to connect their capitals with the valley of the Ohio, without taking into consideration the advantages railways possessed to cross the "back-bone of the United States," the Alleghany mountains. In these States, we find that the talents of their most eminent statesmen were enlisted in favor of canals, prior to the information we now possess of the capacity of a well constructed railroad for transportation. The arguments of able engineers in Europe were first committed to the canal policy from the large private investments in this class of improvements. The advantages of canals, derived from these sources, were presented to the American public in Congressional reports, to prove the great value of canals, and the reverse of the picture for railways was presented, thereby to carry the construction of the Chesapeake and Ohio Canal on a line where a railway from Baltimore to the Ohio is destined to supercede it.

There is some apology for these reports, when we find "*the father of railroads*," Mr. Wood, took the position, (after the opening of the Stockton and Darlington railroad, upon which, the maximum travelling was then 8 miles per hour,) "It is far from my wish to promulgate to the world the *ridiculous* expectation, or rather profession of the enthusiastic speculatist will be realized, and that we shall see engines travelling at the rate of 12, 16, 18 or 20 miles an hour. Nothing could do more harm than their adoption or general improvement than the promulgation of such *nonsense*."

It was under these impressions, that the directors of the Liverpool and Manchester railway offered the premium "of 500*l.* sterling for a locomotive capable of drawing after it, day by day, on a well constructed railway or on a *level* plane, a train of carriages of the gross weight of 20 tons, including the tender, at the rate of 10 miles the hour;" more, they did not ask for;

and to show how perfectly they agreed with Mr. Wood, as to the "*non-sense*" of expecting more, they selected this gentleman as one of the judges. In the short space of ten years, what do we find that American enterprize has accomplished with the locomotive engine. Two hundred tons have been carried at this rate of speed on a level, whilst above 700 tons have been moved both by Norris and Baldwin's engines of Philadelphia, at the rate of 3 to 4 miles per hour. On the Boston and Lowell railroad, with grades of 10 feet to the mile, an engine constructed for the Massachusetts Western railroad, has conveyed a train of 63 cars with 333 tons, at the rate of 12 miles to the hour. In fact, such are the improvements in the locomotive, also in the rail, construction and cost of our railways, that even with our sparce population to the square mile, it is now reduced to a certainty, that on such a thoroughfare as the line of the Erie canal, taking into consideration the passenger business, *freight can be transported cheaper by railway than it can be by the "enlarged canal."*

The period has arrived, and it is high time, that some one ventured to publish it, that, *the main transportation of produce and passengers, from the sea-board to the west, is to be accomplished by railways in preference to canals.* Celerity of motion, with certainty of arrival, *at all seasons of the year*, with the American public, will always command the preference, even were it to cost more for transportation by a railway, which we will not admit will be the case, on such a main thoroughfare, as the line from Buffalo by Albany, to New Yotk.

The consumer will pay an extra charge for transportation by a railway for the first choice of goods. Competition will force rival traders, to supply themselves by this mode of communication two months sooner than the rigor of our climate will allow our canals to open. If this view is correct we come to the conclusion, that hereafter, the rivalry for the early and late trade to and from the west, will be directed mainly to railways, and they must become profitable and indispensable.

It may startle some, and seem perfectlv hetrodox, when we venture to predict, that from this time forward, there will not be found an intelligent legislature, representing the wishes of their constituents, who will vote one dollar towards the construction of any new canal in the State of New York.

We mistake public sentiment, if the expenditures for the *needless* enlargement of the Erie canal, will not have the effect of arresting a work, that it is admitted by all parties, will cost us thirty million of dollars. It has been proved by two tests, lockage and moving tonnage, that the down tonnage has been on the decline for the last five years, from the fact, that the increase of tonnage from agriculture and manufactures does not approximate to the rapid decrease of the tonnage derived from the forrest since the opening of our lateral canals. The Erie canal only gives us, on an average, seven months transportation in a year, over its entire length from Albany to Buffalo.

Boston, we find will soon enjoy a continuous line of railway from her Long Wharf to Buffalo, *the entire year.* Look to the results.

The railroad improvements of Maryland and Pennsylvania give their commercial capitals facilities to approach the valley of the Ohio at all seasons of the year, the effects of which, the city of New York already feels. Our railroads connection with Philadelphia and Baltimore, added to the advantages of the harbor of New York, makes their rivalry less formidable than that of Boston.

It is high time public attention should be directed to the cheapness with which railways can carry freight and passengers, also troops for the defence of the sea-board and the lakes.

It has been satisfactorily tested in Belgium by the late reports of the Chevalier de Gerstner, where the average cost of their railways is $41,000 per mile (double what he finds them to cost on an average in the United States) that *passengers* can be carried with a profit of 5 per cent. nett to the stockholders, at the low rate they charge of 75 cents per passenger per 100 miles. As respects *freight,* we find that "the directors of the Stockton and Darlington railroad have entered into a contract with responsible persons to supply the motive power for this road, at four tenths of a penny or 75 cents per ton per mile." Our population is more scattered than in Europe, but it is believed that one cent (with a passenger business) will pay a profit for conveying one ton one mile.

In the United States our experience in carrying freight is yet limited. In Pennsylvania and Maryland, where the transportation of freight on their railroads is permitted, we find that it is yearly on the increase, with profit to the stockholders.

On the Boston and Worcester railroad, along the line which, there are superior common roads and turnpikes leading into Boston, half the gross receipts of this road, of 44½ miles in extent, during 1838, was $100,292, and for passengers, $112,032. We may ask, what will be the receipts of this railroad, as soon as the line is completed, to take the rich products of the west, centering at Troy and Albany, from the Erie canal, after the Hudson river is closed by ice in November.

By late reports of the legislature of the State of Massachusetts, we learn that the calculations for transportation on their "*Great Western Railway*" from Boston to our State line, at Stockbridge, are upon a large scale. We find that their legislators and scientific men do not consider this improvement, which is to cost $4,200,000 as inferior to the Erie canal, when compared, to promote the interests of their State.

A valuable report from a select committee of both branches of the legislature of Massachusetts, the last winter, took ground, in an able argument to show that the capacity of a *well constructed* railway from Boston to Albany was superior to a canal, and to them "as equal to a second Hudson river, having its source in Albany and termination in Boston." The railroad, they say, "is open for transportation and passengers the *entire* year;

its capacity is not measured by the droughts of summer, nor is its connexion with other sections of our country limited by elevations, to pass which, there is no supply of water for canals. The railway, on the contrary, extends its iron bands of connexion with the whole Union. It is susceptible of extension into every region that our increasing population will require and can support. The ice and snows of winter, are but partial impediments to the daily use of a railroad, whilst canals, on an average, in latitude 43, are closed five months of the year, and this too, at periods when most reqired by the commerce of the country."

The snail's pace of 2½ miles per hour is accomplished by the canals, whilst one locomotive engine can carry from the centre of the city of New York to Buffalo, at the average rate of 10 miles per hour, the usual load of 5 canal boats, (say 150 tons,) of any class of agricultural or manufactured produce, and this too, whilst the Erie canal and Hudson river are frozen up.

It was prejudice and large investments in England that warped their judgments in their reports in 1828 and 9, favorable to canals and adverse to railways. These reports, we repeat, were drawn on largely by our State engineers and canal board in 1835, to prove that a railroad was an improvement to be placed on the medium footing "between a good turnpike and a canal."

This canal mania, led this State to enlarge the Erie canal, and to pass laws for the Chenango, the Black River and the Genesse Valley Canals, over ground, that there is not an intelligent and practical engineer in the United States, but would say, that the interests of the public in transportation and the State in expenditure, would be best promoted by the construction of railways.

The proposed expenditures on the above named canals, which will exceed forty millions of dollars, and (we challenge contradiction to the fact, by a respectable engineer,) will be a burthen to the State, inasmuch as it is now ascertained by experience in Europe as well as in this country, that railways are destined to supecede canals. Such is the genius of the American people with the "go-a-head" principle, so universal in the republic, that nothing can stop their adoption from Maine to Texas, and to all places in the interior.

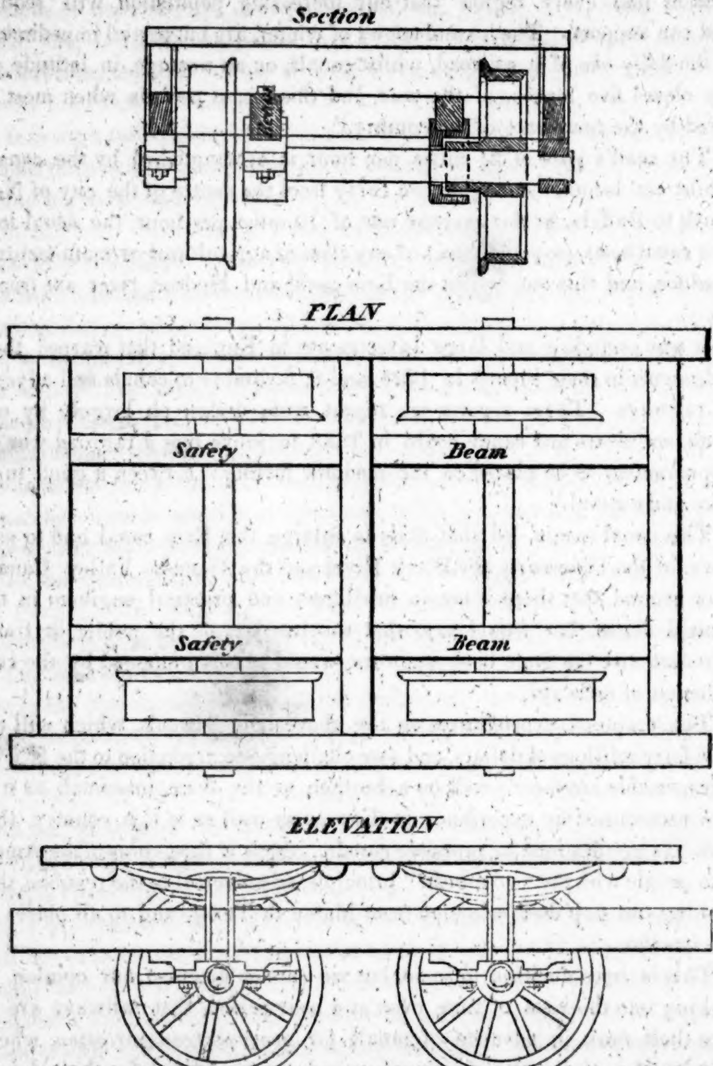
This is new doctrine to some, but we cannot disguise our opinion, in looking into the vista of time, even at a near period, that railways are to take their rank in advance of canals for *general transportation*, where celerity of motion with certainty of arrival are considered, (as they always will be,) by a commercial people.

As a means of *defence*, railways make the seaboard invulnerable to foreign attack. They will nullify nullification. The rapidity and cheapness of inter-communication will dissipate prejudices adverse to the stability of the Union. With railways, "Mason and Dixon's line" and the distinction of "the southern and western States" is done away with. We shall,

by fostering their construction, be bound together with iron clasps, and "E'Pluribus Unum," will be our motto now and forever.

J. E. B.

KITE'S PATENT SAFETY BEAM.



In these days of accident and disaster, we heartily welcome every improvement conducing to public safety, and most willingly give place to every new instance of the utility and success of such improvements. We have before called the attention of our readers to Mr. Kite's invention most greatly deserving its title "safety beam." From an examination of the model, which deserves high credit for its great simplicity, and from the

results of an accident which passed under our own observation, and in which we were satisfied that fatal consequences and great danger to the cars were avoided by the fortunate employment of the "safety beam," we were convinced of the great importance of bringing this invention into notice. But as on most of our nothern railroads, the old four wheel cars are still used, we could hardly expect that this improvement or any other of its nature, should be adopted, where such utter disregard was paid to public comfort and safety.

A recent occurrence on the Philadelphia, Wilmington and Baltimore railroad, has added a new testimony to the usefulness of this contrivance. We have seen a certificate from the conductor of the train and superintendant, which gives the following account of the matter:

"On the passage of the evening train of cars from Philadelphia, an axle of one of the large eight wheel passenger cars was from some cause broken, but from the peculiar construction of the cars, called (with truth) the safety beam principle, invented by Mr. Joseph S. Kite, superintendant of the Philadelphia, Germantown and Morristown railroad, the accident was entirely unknown to any of the passengers, or in fact to the conductor himself, until the train, as was supposed, from some circumstances attending the case, had passed several miles in advance of the place where the accident occurred, whereas, had the car been constructed on the common plan, the same kind of accident would unavoidably have much injured the car and perhaps have thrown the whole train off the track, and severely injured if not killed many of the passengers."

It is also stated that "the car, the axle of which was broken, was run from the place where the break was discovered, a distance of *eleven miles*, without any detention, excepting that of removing the passengers to another car, which was deemed advisable, only on account of the friction of the safety hubb, which commences to act immediately on the breaking of an axle."

If this were the only case in which peril of life and limb, to say nothing of damage to cars, had been avoided by the employment of Mr. Kite's contrivance, it would be a good and sufficient reason for advocating the use of it as conducive to public safety. On the contrary, several cases of a similar character are known to have occurred, and the "safety beam" has now become quite common on most of the southern roads. Nearly, if not all of the five cars built of Messrs. Betts, Pusey and Harlan, of Wilmington, Delaware, contain this valuable improvement, and the high reputation of the builders as well as the merit of the invention, have, by means of this happy combination become extensively known.

The miserable policy of adhering to the use of the most antiquated form of four wheel cars, merely because a stock of them has been provided and *must be worn out* before others are purchased, is so short-sighted that it would hardly be thought possible of adoption in an intelligent railroad direction. Yet that such policy has been adopted, and for no other reason,

cannot be denied; as it has been openly acknowledged by railroad companies. How stockholders can patiently see their interest thus mismanaged is more than we can understand. To those companies who, sensible of their great advantages, both in point of comfort, safety and economy, have adopted or are about to adopt the eight wheel car, we most earnestly recommend the use of Mr. Kite's patent safety beam. It is cheap and simple and calculated to increase the confidence of the travelling public, *and if by means of it, one life is saved, its cost is more than repaid.*

For the information of the writer of the following communication we will state that we had a conversation not long since with Mr. Fessenden in relation to his improved *Rail* and *Chair*, and that he then promised to furnish us with a drawing and description of them for publication, if his other engagements would permit; we will, however, now, in accordance with the request of "An early friend of Railroads"—and we know him to have been such *to his cost*—renew our request to Mr. Fessenden to furnish, at his earliest convenience, the drawings and descriptions called for; and also express the hope that he will readily contribute such other information useful to the cause as his long and successful experience in the construction of Railroads must have furnished him with. We hold that every Engineer and friend of Railroads owes it to the cause to publish facts which his experience may have furnished him with, tending to the improvement of the system.

For the American Railroad Journal and Mechanics' Magazine.

Gentlemen—I find in No. 7, vol. 3, New Series, p. 216, of the Railroad Journal, a Report made by J. M. Fessenden, Esq., Civil Engineer, in relation to the Eastern Railroad in New Hampshire, which I read with pleasure, as it shows that "the times" have not caused a suspension of operations on the eastern railroad from Boston—a link so important in "the *great Atlantic chain*," which, when completed, from the capital of Maine through the principal Atlantic cities to New-Orleans, and from New-Orleans to the great northern lakes and thence back again through the interior to Boston, will serve to unite more closely and more permanently—because it will ensure a more frequent intercourse, and a more intimate acquaintance of the people of this great nation, than *any other* measure which ever has, or probably *can* be adopted.

I have understood that Mr. Fessenden has adopted on this road a rail and chair of an improved form, and was in hopes, when I saw his report, that I should find in it a description of them, but was disappointed in this respect; I will therefore thank you to request him to give a description of his *Rail* and *Chair* for publication in the Journal—the proper medium as I consider it, of communication between the profession and the public, that its superior advantages, if it has any, may be availed of by others.

Your early attention to this request will much oblige one who has read

the Journal from its commencement, and who is as much gratified as you can be to witness its improved appearance under the "new arrangement."

An early friend of Railroads.

The following strong testimonial to the merits of American Locomotive Engines, has an additional value in coming from a most accomplished European engineer, who has in person, or by his assistant, examined *every known railroad in the world.* That the Chev. de Gerstner should so heartily recommend the engines of Baldwin, Vail and Hufty, is a sufficient confirmation, if any were needed, of their value. It is already known that two American houses have shipped engines, in compliance with European orders, and we most sincerely hope that the testimonial of Chev. de Gerstner, will increase the demand in Europe. The advantages for which he recommends the engines of Messrs. B., V. and H. are of the utmost value.

"Having visited within ten months nearly all Railroads in the United States, and having collected the most useful information concerning them, which I intend to publish during my further stay of one or two years in this country, I certify with pleasure that I received every where the best testimonials from the Presidents, Engineers and Superintendants of railroads, in regard to the workmanship and the performances of Mr. Baldwin's Locomotives. Owing to the peculiar construction of these engines, I observe that they are remarkably easy to the road, even where light rails are used. I regard them, therefore, after a careful examination of the results obtained, as the best machines used on American railroads, and recommend them strongly to all railroad companies in Europe.

F. A. Chev. de Gerstner.

Some time since we took occasion to notice a work of Mr. Charles Ellet on the "Laws of Trade." At no period of our progress in Internal Improvement has the necessity for *exact* demonstration upon this subject been so great as at present, and this feature in the work induced us to give it a hearty welcome. We are satisfied that in presenting this work to the profession, Mr. Ellet has determined to submit his labors to the most careful and accurate examination, allowing it to speak for itself, while he is perfectly willing to defend his mathematical demonstrations of the "Laws of Trade." In the hope that our engineers will warmly second this first attempt to elucidate a most important, but hitherto unexplored branch of science, we invite their attention to the Card upon our cover.

We are again indebted to P. G. Voorhies, Esq., of Wilson's Landing, on Red river, (below Alexandria,) La., for a series of Meteorological tables, continued down to the present time. We value these observations the more highly for being the only data for ascertaining the mean temperature of that part of our country. Mr. Voorhies is entitled to the thanks of the scientific community for his industry in continuing these observations.

ECONOMY OF FUEL.

Perhaps there is no subject of more general importance, both in a scientific and a national point of view, than that which forms the title of this

paper, more especially at the present time, when owing to the vast and rapid augmentation of steam power, whether as applied to mines, manufactures, locomotive or maritime purposes, the consumption of fuel has increased to an almost incredible extent. When to these are added the enormous quantity consumed in the iron works, besides that which is annually exported to India, the Colonies, and foreign parts, we cannot but contemplate the probability of the exhaustion of our coal beds (there being no reproduction of coal in this country, since there are no known natural causes in operation to form other beds of it) otherwise than as a national calamity, involving the destruction of a great portion of our manufacturing and commercial prosperity. Nor is the period so very remote when the coal districts, which at present supply the metropolis with fuel, will cease to yield any more. The number and extent of all the principal coal beds in the north of England have been ascertained, and calculations made, by which it would appear that the supply will be probably exhautsed in a period of from 350 to 400 years.

Professor Buckland, in his evidence on this subject, estimates the duration of the coal in these districts, at the present rate of consumption to be 400 years.

Professor Sedgwick, who is well acquainted with the coal strata of Northumberland and Durham, gave his opinion, respecting the duration of the coal of these counties, as follows:—

I am myself convinced, that with the present increased and increasing demand for coal, 400 years will leave little more than the name of our best coal seams.

And he further adds:—

Our northern coal field will probably be in the wane before 300 years have elapsed.

Already this event has occurred in the coal fields of Staffordshire, Warwickshire, and Leicestershire, once amongst the most important in the kingdom, and now nearly exhausted; owing to which cause the manufacture of iron, for which these districts were for a long time celebrated, has been nearly discontinued in those counties, and the chief seat of the iron trade is now removed to Monmouthshire and Glamorganshire; in which two counties alone there are upwards of 100 blast-furnaces for the smelting of iron at present at work, which may be equal to the production of about 400,000 tons of iron a year. Now it is a known fact, that from five to six tons of coal are required for the production of one ton of iron, consequently 2,400,000 tons of coal would be consumed in South Wales in the iron works alone.

The quantity of iron made in Great Britain in the year 1836 is stated in the "Mining Journal," of October 7, 1837, to be about one million of tons, in the manufacture of which six millions of tons of coal would be consumed.

The total consumption of coal in Great Britian in the year 1827 was stated to be 22 millions of tons, and the quantity exported to India, the Colonies and foreign parts about two millions of tons. It is probable, however, that even this amount was considerably under the actual quantity consumed; and if we take into consideration the immense increase that has taken place since that period for the purposes of steam navigation and locomotive engines, we shall probably be considerably under the mark in stating the whole quantity of coal consumed in great Britain, exclusive of that which is exported at 30,000,000 of tons, to which must be added *one-third* of the whole amount, or 10,000,000 of tons, *for coal left and wasted in the mines.* (See "Holme's Treatise on the Coal Mines," who states the waste of small coal at the pits' mouth to be one-fourth of the whole, and

that in the mines one-third.) This enormous proportion of coal left and wasted in the mines seems so incredible as to require some further explanation, and this cannot be better given than in the words of an eminent geologist Dr. Buckland, in his "Bridgwater Treatise," who says:—

We have for many years witnessed the disgraceful and almost incredible fact that more than a million of chaldrons (1,350,000 tons) per annum, being nearly one-third part of the best coals produced by the mines near Newcastle have been condemned to wanton waste, on a fiery heap, perpetually blazing near the mouth of almost every coal pit in that district. This destruction originated mainly in certain legislative enactments, providing that coal in London should be sold, and the duty upon it rated, *by measure* and *not by weight.* The smaller coal is broken the greater the space it fills; it became, therefore, the interest of every dealer in coal *to buy it of as large a size*, and *to sell it of as small a size as he was able.* This compelled the proprietors of the coal mines to send the large coal only to market, and to consign the small coal to destruction.

In the year 1830 the attention of Parliament was called to these evils, and pursuant to the report of a committee, the duty on coal was repealed, and coal directed to be sold by *weight, instead of by measure.* The effect of this change has been that a considerable quantity of coal is now shipped for the London market in the state in which it comes from the pit, that after landing the cargo, the small coal is separated by skreening from the rest, and answers as fuel for various ordinary purposes, as well as much of the coal which was sold in London before the alteration of the law.

The destruction of coal on the fiery heaps near Newcastle, although diminished, still goes on however to a frightful extent; that ought not to be permitted, since the inevitable consequence of this practice, if allowed to continue, must be, in no long space of time, to consume all the beds nearest the surface, and readiest of access to the coast, and thus enhance the price of coal in those parts of England which depend on the coal field of Newcastle for their supply: and finally, to exhaust this coal field at a period nearer by at least *one-third*, than that to which it would last, if wisely economised.

The concluding observations of Dr. Buckland, on this important subject, are so much to the purpose, that it will be a sufficient apology for introducing them here. He proceeds thus:—

We are fully aware of the impolicy of needless legislative interference, but a broad line has been drawn by nature between commodities annually or periodically reproduced by the soil on its surface, and that subterranean treasure and sustaining foundation of industry which is laid by nature in strata of mineral coal, whose amount is limited and which when once exhausted is gone for ever. As the law most justly interferes to prevent the wanton destruction of life and property it should seem also to be its duty to prevent all needless waste of mineral fuel, since the exhaustion of this fuel would irrecoverably paralize the industry of millions.

The tenant of the soil may neglect or cultivate his lands, and dispose of his produce as caprice or interest may dictate; the surface of his fields is not consumed, but remains susceptible of tillage by his successor; had he the physical power to annihilate the land, and thereby inflict an irremediable injury upon posterity, the legislature would justly interfere to prevent such destruction of the future resources of the nation.

This highly favored country has been enriched with mineral treasures in her strata of coal, incomparably more precious than mines of silver or of gold. From these sustaining sources of industry and wealth, let us help ourselves abundantly, and liberally enjoy these precious gifts of the Creator;

waste of small coal at the pits' mouth to be one-fourth of the whole, and

but let us not abuse them, or by wilful neglect and wanton waste, destroy the foundation of the industry of future generations.

Might not an easy remedy for this evil be found in legislative enactment, that all coals from the ports of Northumberland and Durham, should be shipped in the state in which they come from the pits, and forbiding by high penalties the skreening of any sea borne coals, before they leave the port at which they are embarked. A law of this kind would at once terminate that ruinous competition among the coal owners, which has urged them to vie with each other in the wasteful destruction of small coal, in order to increase the profits of the coal merchant, and gratify the preference for large coals on the part of rich consumers; and would also afford the public a supply of coals of every price and quality, which the skreen would enable him to accommodate to the demands of the various classes of the community.

A farther consideration of national policy should prompt us to consider how far the duty of supporting our commercial interests, and of husbanding the resources of posterity should permit us to allow any extensive exportation of coal, from a densely peopled manufacturing country like our own; a large proportion of whose present wealth is founded on machinery, which can be kept in action only by the produce of our native coal mines, and whose prosperity can never survive the period of their exhaustion.

At the last meeting of the British Association at Newcastle, Dr. Buckland read a paper on the application of small coal to economical purposes, in which he referred to the well known enormous annual waste of coal at the mouths of the various pits near Newcastle, and stated that, owing to what he had said on the subject in his Bridgewater Treatise, the attention of a benevolent individual had been called strongly to the subject. That individual had succeeded in agglutinating the small particles of coal into a firm compact mass, by a process at once simple and cheap; and he believed he had taken out a patent for the method. There would be even an economy in using this coal for many purposes, as it occupied *one-third* or *one-fourth* less space, when packed in boxes, than coal in its ordinary state.—Specimens were exhibited, which had a firm compact appearance, and Dr. Buckland stated that by the direction of government, trials had been made under the inspection of competent persons, and that success had been complete, the combustion being at least as productive as that of coal in its common state.

The experiments alluded to by Dr. Buckland, took place at Woolwich dockyard in August last, under the superintendence of Messrs. Kingston and Dinnen, two experienced engineers. The "prepared fuel," as it was termed, is a composition of skreened coal, river mud and tar, cast into blocks of nearly the size and shape of common bricks. One great advantage attending this form is that a much larger quantity, weight for weight, may be stowed in the hold of a sea going steam vessel, than of common coal, and it is besides not liable to shift its position, like the latter. An engine was worked with this prepared fuel, and the consumption for 6 hours, 45 minutes, was 750 pounds. The same engine required 1,165 pounds of north country coals to keep it going for the same time, showing a saving of 415 lbs. in favor of the prepared fuel.

At another experiment, Welsh coal was used, and 1,046 lbs. were consumed, while 680 lbs. of the prepared fuel easily performed the same work in the same time. It was also remarked that it requird about 50 lbs. less of the prepared fuel to get the steam up, than of common coal, and that the steam was maintained by it at a more even temperature, with very little feeding.

(To be continued.)

ourselves abundantly, and liberally enjoy these precious gifts of the Creator;

MIXTURE TO PREVENT THE INCRUSTATION OF STEAM BOILERS.—MEMORANDUM

Admiralty, 8*th Jan*., 1839.

The Lords commissioners of the Admiralty, in calling the particular attention of all officers in command of steam vessels to the annexed abstract of a report from Lieut. Kennedy, late commanding Her Majesty's steam vessel Spitfire, and Mr. Johns, the first engineer of that vessel, are pleased to direct that the mixture therein described, which has been proposed by the latter officer to prevent incrustation on the inner surfaces of boilers, be generally made use of for that purpose in all Her Majesty's steam vessels. The directions as to the proportions of black lead and tallow are to be strictly followed, and the mixture is to be applied as often as circumstances will admit of it, every opportunity being taken as heretofore to remove from the boilers the small deposit which will still be formed.

Report of Lieut. Kennedy and Mr. Johns, engineer of Her Majesty's steam vessel Spitfire.—We beg leave to state that the proportion for a first class steamer should be about sixteen pounds of melted tallow and two of powdered black lead, well mixed and laid on with a common tar brush over the inside of the tubes and fire places, and other inside parts of the boilers that can be got at, every time after a passage of any length, as the more often it is done the better. *The boilers are to be blown out as usual every two hours*, for it is not to be supposed that, without proper attention being paid to this necessary duty, this mixture will prevent the incrustation from forming; the blowing off takes great part of it away while in solution and what remains, after short trips, may be swept off by hand with a piece of oakum; and after long trips, should a thin incrustation remain on the plates, the slightest blow will cause it to fall off in large flakes covered with black lead on the inner side, without the use of the chipping hammer, which only makes the plates rough and more ready to receive and retain the deposit, and otherwise injures the boilers, causing much labor to the men — Ten pounds of tallow and one and a half of black lead would be enough for the smaller steamers after each voyage; or after a very long voyage, that quantity used twice.

The Spitfire ran from Malta to Corfu, from Corfu to Malta, from thence to Gibraltar, and back to Malta, with only one application of the mixture, from want of time.

We consider that the said mixture, if *frequently and properly applied, the same attention being paid to blowing off as before*, will cause the boilers to last at least a *fourth* longer, and will be found a great saving in coals and labor, doing away with the necessity of fresh water, (the Spitfire having had only one supply in her boilers for eighteen months;) and we find that the longer and more often it is used the cleaner the boilers look inside. —*Nautical Magazine.*

"DESCRIPTION OF A SAWING MACHINE FOR CUTTING OFF RAILWAY BARS."—BY JOSEPH GLYNN, M. INST. C. E.

The advantage of having the ends of the railway bars cut as nearly square as possible, that they may truly abut against each other, is so great, that many attempts have been made to effect it. The author in this communication describes the method which is adopted at the Butterfly Works in the manufacture of the rails for the Midland Counties railway. In general the end, rough and ragged as they come from the rolls, are separately reheated and cut off by the circular saw; but accuracy in this case depends on the workmen presenting the bar at right angles to the plane of the saw.

As this cannot be insured, the difficulty may be obviated as follows:—The axis of the saws and the bed of the machine, which is exactly like that of a slide lathe, are placed at right angles with the line of the rolls in which the rails are made; the saws are fixed in headstocks and slide upon the bed, so as to adjust them for cutting the rails to the exact length, and are three feet in diameter and one-eighth of an inch thick, with teeth of the usual size, in circular saws for wood, and make 1,000 revolutions per minute; the teeth are in contact with the hot iron too short a period to receive any damage, but to prevent all risk the lower edge of the saw dips in a cup of water. The saw plate is secured between two discs of cast iron faced with copper and exposed only at the part necessary for cutting through the rail. The rail on leaving the rolls is hastily straightened with wooden mallets on a cast-iron plate, on which it lies right for sawing and sufficiently hot: thus a considerable saving of time, labor and heat is effected. The rail is brought into contact at the same time with the two saws, and both ends are cut off by one operation. If the saws be sharp and the iron hot, the 78 lb. rails are cut through in twelve seconds. The rail on leaving the saws, is placed in a groove planed in a thick cast-iron plate; thus all warping is prevented. The author then describes certain mechanical arrangements, which are exhibited in detail in the drawing accompanying the communication.—*Civil Engineer and Architects' Journal.*

Railroad between the Danube and the Black Sea.—The establishment of a railroad between Tschernowoda and Kostensche, which was to open a direct and speedy communication between the Danube and the Black sea will not be continued this year, or even for some time, and in fact will not be completed till the Porte gives its assent to the project. The marshy ground unfavorable to canalisation has been inspected, and the operation compared with the measurement already made by some Prussian officers in the Sultan's service, but the project of opening a canal appears to be abandoned. The railroad in question is not to go from Tschernowoda, but from Hirsowa, which is at no great distance, to Kostensche, where the rampart or wall of Trajan formerly commenced, a spot famous in ancient history as the place of Ovid's exile. Meantime the railroad in its present state is to be made use of for the transport of goods and provisions. Were the railroad once executed, a distance of more than two days would be gained, and the undertaking would also be of great importance for the trade and navigation of the lower Danube.—*Idem.*

Iron Ships.—The *Ironsides,* the first sailing vessel constructed of iron which has ever crossed the Atlantic, has just returned to Liverpool, with a cargo of cotton from Brazil, after a passage of forty days, though during the whole trip light winds prevailed. This has completely established the practicability of navigating the ocean in ships of iron. The compasses, whose action it was predicted would inevitably be deranged, worked very correctly; and the superiority of the material of which the vessel is built is proved by the fact, that in the course of the whole voyage it was never once necessary to use the pumps. In fact her hull is absolutely water tight. The success of this experiment is highly important, occurring, as it does, at a time when timber is scarce and dear. So little has the *Ironsides* suffered from exposure to wind and weather, that her appearance would induce the belief that she had but lately been launched. Her tonnage is 264;—draft of water aft, 8 ft. 7 in. and forward 8 ft. 3 in. [This is a very important notice, and we commend it to the consideration of our commercial

readers. In the adoption of iron ships several points are to be considered. Economy and durability, we suppose, are in their favor. Their sailing qualities seem by this experiment to be at least equal to those of wooden ships; but these depend less upon the materials of which a vessel is built than upon her model. The thing that strikes us most, however, is the extreme buoyancy of the iron ship. She is said to be 264 tons—we presume by the new mode of admeasurement: if so, she carries probably 400 tons, and yet she draws only about 8 and a half feet of water, or perhaps, with a heavier cargo, nine and a half feet or ten feet at the utmost! Now, the great drawback upon the profit of the coasting trade, at least in this part of England, is the impossibility of constructing a vessel that will carry a large cargo with a draft of water suitable to our tide-harbors. A vessel of 100 tons will draw as much water as this ship; and if the burden be carried up to 150 or 200 tons, the draft of water becomes a serious impediment, and what is gained in freight is lost in frequent and vexatious delays, and in injuries sustained from grounding on bars and sand banks. But a vessel of 100 tons cannot be sailed in winter, and ought not to be sailed at any time, with fewer than four men and a boy; making for four such vessels twenty hands; while such a ship as the *Ironsides* might be salied with twelve or fourteen hands at all seasons. But will an iron ship take the ground with a heavy cargo? That seems to us the principal question; and if it be found that she will—if it be found that a ship of large burden can be so constructed as to be fit for all the purposes of the coasting trade, and capable of enduring the severe trials to which the best and strongest ships are exposed in it, and yet so buoyant as to enter all the Welsh and Cornish ports, at neap tides—if this be ascertained, we may expect in a monht or two, to see half the smiths of Hayle and Neath turned into shipbuiledrs.—*Cornwall Gaz.*

PAMBOUR ON THE STEAM ENGINE.

Sir—As you have often, at different times, noticed M. Pambour's works on the steam engine, allow me to direct your attention to his table referred to in page 92 vol. 2 of your Journal. In most cases therein the practical results differ very widely from the theoretical. Now may not this be explained partly by taking into account the gradient immediately before the place of trial, or in other words, the accelerating or retarding force with which it enters it? For instance in the case of the Fury, August 4, 1834 (page 229 of Pambour) it drew 50 tons at 24 miles per hour. Now the theory gives 29 miles; but immediately before the trial plane comes a descending one of   . This is omitted in the table.

In example, page 228, the Fury drew 244 tons at six miles per hour. By the theory it could not have moved the load. May this result be attributed to the accelerating force of the plane it had just left, or altogether to the incorrectness of the theory?

I am Sir,

A constant reader.

London, April 12, 1839.—*Civ. Eng. and Arc. Jour.*

Suspension Bridges.—The largest suspension bridge in this country is that across the Menai Strait, with a span of 560 feet; the next in point of size, is that at Montrose, which is 432 feet in span: we have been much gratified by the inspection of a report and plan of a third, which will rival these stupendous works of art, both in magnitude and importance; for while they have but one span each, of the above dimensions, that to which we are alluding projected by that able engineer Mr. J. M. Rendel, will

have two of 450 feet each, and a whole length (with the side openings) between the abutments of 1125 feet. The scite to the proposed bridge, is at Newnham, on the Severn in Gloucestershire, where there is at present a ferry, which has the great inconvenience of being entirely navigable only half an hour before and after high water. The great advantages of such a work will be materially felt in the adjacent country, by the coal and other mines of Dean Forest, becoming easier of access, thereby producing a considerable reduction of price, besides the convenience it will secure of a direct route across the Severn to the southward of Gloucester. The various drawings by which the proposed bridge is illustrated are admirably executed, and convey both in point of topographical, geological and perspective detail, as complete an idea of this magnificent proposed work and its locality as can be expressed by the artist on paper.—*Nautical Magazine.*

Receipts on the Harlem Railroad.—From October 1st to 25th inclusive, 1839, fare was $7,722 83

From October 1st to 20th inclusive, 1838, fare was 5,621 16

$2,101 67

Increase in the last 20 days, over the corresponding period of last year $2,101 67, equal to $105 per day, or 37¼ per cent increase.

The number of passengers carried on the 15th street line, from 1st to 20th of October inclusive, was fifty six thousand two hundred and sixty five, at six cents each.

LOCOMOTIVE ENGINES.

We give the following communication from the Pennsylvania Enquirer with pleasure—as we do all similar accounts of "improvements of this particular breed of *horses*"—and we do it the more readily, as it affords us an opportunity again to call attention to the eminent success of the gentlemen therein named, in their efforts to "improve the breed;" and to express the opinion that more real and valuable improvement has been made in this "breed," *in the locomotive shops* of the United States within the last *seven* years, than has been effected in the old fashioned horse by all the "race courses" in the Union in fifty years.

Mr Editor:—My attention was directed to-day to a new Locomotive Steam Engine, manufactured for the Philadelphia, Germantown and Norristown Railroad Company, by Messrs. Baldwin, Vail & Hufty, the extensive manufacturers on Broad street. The engine has been in use several days, and performs to the entire satisfaction of both makers and owners.

The peculiarity in the arrangement is, that there is no frame around the boiler, and none is required. The machinery is attached to the naked boiler—is all outside of the wheels, directly under the hand and eye of the engineer, and is of that simple and permanent arrangement so peculiar to all of Mr. Baldwin's designs. I had supposed that little room was left at this time for simplification and improvement in Locomotive Engines, but shall not be at all surprised after this, to learn that Mr. Baldwin has pruned the little left of former English arrangements, in his locomotives. No person can examine this machine and not feel proud of her as a specimen of American skill, both in the design and the mechanical execution of the work. I have seen many engines of English and American manufacture

and do not hesitate to say that this is the most perfect piece of work I ever examined. She is named "Fort Erie," and appears, by the plate on her side, to be the 138th engine built in Baldwin's shop. Much credit is due Col. Watmough the President of the company for his indefatigable exertions in behalf of the stockholders and the public, in procuring good and efficient locomotives, and in the general improvement of the condition of the road. I have observed, with much pleasure, that every thing is carried on under his own personal direction and inspection; and do not believe that any rail road in this country is possessed of better machinery and accommodations and more obliging agents and officers. I am not a stockholder, or in any way interested in the work, but deem the above remarks due to merit.

One of the People.

Steamers from the Clyde to New York.—A joint stock company is now forming in Glascow, for carrying passengers and merchandise between the Clyde and New York, by means of an iron steam ship of great power and capacity, to sail at the rate of at least sixteen miles an hour, thereby making a passage in about ten days, and enabling this vessel to make a monthly voyage to America. The capital to be 50,000*l*.—*Glasgow Chronicle.*

THEORY OF THE STEAM-ENGINE.

CHAPTER I.—PROOFS OF THE INACCURACY OF THE ORDINARY MODE OF CALCULATION.

(Continued from page 287.)

The regulator, then, can make no change in the pressure in the cylinder, but this is what happens. The quantity of steam of a given density, which flows through a determined orifice, being in proportion to the area of that orifice, it follows that when the opening of the regulator is contracted, the *quantity* of steam, at the pressure of the boiler, which passes into the cylinder, is thereby diminished; nevertheless the same quantity is still generated in the boiler. The steam which has ceased to find an issue towards the cylinder, will then accumulate in the boiler, and will there rise to a greater and greater density and elastic force, till at length it finds an issue somewhere; till for instance, having attained the pressure necessary to raise the safety valves, it escape into the atmosphere. Then a balance will be established, according to which the surplus of steam generated above what can reach the cylinder, will find a constant issue by the safety valves; and the rest will pass through the orifice of the regulator and go into the cylinders to produce the motion of the piston. From this moment all will persevere in the same state, and the pressure in the boiler will continue as high as it must be, to keep the safety-valve open and give egress to the steam, as quickly as it is produced.

Hence it is plain that the contracting more or less of the regulator can have no action on the pressure in the cylinder, but that it has a very direct action on the pressure in the boiler.

2. We have just said that, according as the aperture of the regulator is contracted, the pressure of the steam will rise in the boiler and its density increase at the same time; and so long as the steam shall not find an opening to escape entirely as fast as it is produced, this increase of density and elastic force will continue; for we suppose that the same mass of steam per minute is still generated in the boiler, and that the fire is maintained in the same state. Now the steam is retained in the boiler by two obstacles; the orifice of the regulator which opposes its passage on account of the density,

and the safety-valve which opposes its passage on account of the pressure. Two cases then may now occur, according to which of the two obstacles shall give way first; either the steam becoming more and more dense, will in the end so reduce its volume, as to issue entirely by the orifice of the regulator, notwithstanding the contraction of the latter; or else the safety-valve, opposing less resistance to the elastic force than the narrowed orifice opposes to the density, the steam will escape by the safety-valve.

In the first of these two cases, then, the engine will be thus regulated: in the cylinder, as invariably, the pressure of the resistance; and in the boiler the pressure necessary for the corresponding density of the steam, to admit of its issuing entirely by the aperture afforded by the regulator.

And in the second case, the engine, on the contrary, will be thus regulated; in the cylinder still the pressure of the resistance, and in the boiler that of the safety-valve.

We must now consider separately each of these cases. Let us suppose that the safety-valve being set at a very high pressure, and the orifice of the regulator, on the contrary, being *but moderately* contracted, the steam accumulating in the boiler, has acquired the density which allows its issue by the orifice, before it has acquired the pressure which procures its escape by the safety-valve. Then it will happen that the *total* quantity of steam produced will pass into the cylinder, that it will there assume the pressure of the resistance, dilating itself in proportion; and by dividing the volume of the steam thus dilated by the area of the cylinder, we shall always have the velocity of efflux by the cylinder, which is nothing else but the velocity of the piston. Thus all will go on as before in the engine, and consequently the effects produced will always be given by the same formulæ, P being made of course to express the new pressure produced in the boiler, and S the new vaporisation, if that vaporisation has changed in consequence of the change of pressure.

Let us now suppose that the safety-valve is set at a low pressure, and that the regulator, on the contrary, is considerably contracted; so that the steam rises the valve before it acquires the density that would permit it to issue entirely by the regulator. The valve will then be raised, and a part of the steam which continues to be generated in the boiler, will be lost in the atmosphere; and necessarily the effects of the engine will be by so much diminished. But let it be observed, that, with respect to that part of the steam which is not lost, that is the part which finds an issue towards the cylinder, it may always be truly said, that it will there assume the pressure of the resistance, and act in the same manner as the total mass of the steam did before.

The only difference will be then, that the effects produced, instead of being due to the *totality* of the steam, will now be due to a portion only of that steam.

Thus, provided our formulæ take account of this difference, they will thereby take into account the whole change that has taken place. Now this is precisely what they do, for we have said that the quantity S, in those formulæ, represents the *effective* vaporisation of the engine, that, in fact, which is really transmitted to the cylinders; or, in other words, the *total* vaporisation, minus that which is lost by the safety-valve. It will, then, suffice to substitute for S the real value proper to the case, and the formulæ will continue to represent what passes in the engine.

As the *total* quantity of water evaporated in a given time is measured directly in the feeding apparatus, all that remains to be sought is the means of estimating that which is lost by the safety-valve, in order to subtract it from the former. This valuation is easily made, by noting how much the

valve is raised at the moment of the loss, which the length of the valve-levers, and the graduated scale with which they are furnished, render very easy to do; afterwards the regulator must be completely closed, so as to force the whole of the steam produced to escape by the valve, and note taken again of the degree of elevation which this will cause to the valve. Then the proportion of the first elevation to the second will give the ratio of the steam lost to the whole steam produced. This is the means we have employed for locomotives. Should this valuation not appear sufficiently precise, the waste steam may be condensed in a separate vessel, and the quantity of water measured. It will always, then, be easy to know the *effective* vaporisation of the engine, and consequently, by introducing it into the formulæ, we shall continue to have the true effects produced.

In the two preceding cases we have supposed that the boiler continues, after the contracting of the regulator, to produce the same quantity of steam. A third case, however, may occur, namely, that wherein the engineer shall lower the *damper*, the moment he sees the valve blow, and reduce his fire so as to stop the blowing of the valve. Then the mass of steam produced per minute will diminish; but since it is clear that the quantity which is produced, however small it may be, will always act in the engine in the same manner it follows that, provided we substitute this new evaporation in the formulæ, we shall have also the new corresponding effects. Thus, for this third case as for the other two, the formulæ will always satisfy the exigencies, as soon as the substitutions proper to the supposed case shall have been made.

3. It will now be proper to examine what changes the effects of the engine will undergo in the three preceding suppositions. We have seen that the proposed formulæ will always give those effects, on the proper substitutions being made in them. Let us then examine the results of those substitutions.

In the first case, to wit, the fire continued at the same degree of intensity, and the orifice narrowed, though not sufficiently to make the valve blow, the pressure P in the boiler becomes greater. But in the exposed formulæ, the pressure P figures only as multiplied by m, which is the *relative* volume of the steam. This volume being inversely as the density, and the density itself varying very nearly in the direct ratio of the pressure, it follows that, unless a very great change of pressure take place, the product m P will remain constant. If it be supposed, as is generally admitted, that the evaporation of a given boiler is the same under different pressures of the steam, the quantity S will not vary either. In this case, then, the formulæ will give the same results; and consequently the engine will produce the same effects, after the contracting of the regulator as before that contraction was made.

In the second case, to wit, contraction of the regulator, attended with blowing of the safety-valve, there is still increase of pressure in the boiler, which, as we have just seen, produces no change in the effects. But moreover there is a certain loss by the safety-valves, and that loss diminishes by so much the *effective* vaporisation S. There will then be a diminution of effect precisely proportional to the quantity of steam lost by the valve, which we have given the means of measuring.

Finally, in the third case, to wit, contraction of the regulator, accompanied by a reduction of the intensity of the fire, the blowing of the safety-valve will be suppressed only by producing a smaller mass of steam in the boiler. But since this mass of steam, generated and transmitted to the cylinders, is less than before the contraction of the regulator, it follows that the effect produced by the engine, or the result given by the formulæ, will

be reduced just so much. Thus this third case is similar to the second, and will similarly be attended with a reduction of effect.

The first of the three cases which we have just presented, takes place without the smallest attention being paid to it, whenever the orifice of the regulator is but slightly diminished.

The second occurs almost continually in locomotive engines, because these having to overcome very variable resistances, according to the inclinations of the road they traverse, it is necessary to maintain an intense fire, and to keep the engine always ready to develope on an emergency an increase of power.

The third is that which happens generally in stationary engines, when the regulator is pretty much contracted, because the regulator, in those engines, being never reduced but when the work of the engine requires less force, the engine man takes advantage of that circumstance to diminish the intensity of the fire, and to produce no more evaporation than what is strictly necessary.

These three cases may then occur in the different engines, but the exposed formulæ will always adapt themselves to them.

Section VIII.—Of the differences which exist between the theory proposed and the ordinary theory.

In terminating the general exposition of our manner of viewing the action of steam in steam-engines, we will resume in a few words the differences existing between the method we propose and that which has been in use hitherto.

1. The ordinary theory passes from the theoretic effects to the practical by means of a constant coefficient.

Ours rejects entirely the use of that coefficient, which we regard as resulting from a fundamental error in the calculation of what are termed the theoretic effects.

2. The ordinary theory acknowledges not knowing the pressure in the cylinder; it seeks to deduce it from that of the boiler.

Our theory determines, *a priori*, the pressure in the cylinder, as being, not equal nor proportional to that of the boiler, but equal to that of the resistance on the piston.

3. The ordinary theory determines the load which an engine is capable of drawing, without taking the velocity into the calculation. That is to say, it maintains that the engine will always draw the same load at any velocity that can be imagined.

Our theory brings the velocity into the calculation in such sort, that the greater the velocity the less will be the load the engine can draw.

4. The ordinary theory calculates the evaporation of the engine for a resistance and a velocity given, exclusively of any consideration of the resistance; that is to say, it maintains again that the evaporation necessary to effect the motion shall be independent of the resistance to be moved.

Ours, on the contrary, introduces the load and the velocity into the calculation.

5. The ordinary theory has no means of calculating the velocity that an engine will assume with a given resistance.

Ours gives this calculation with the same simplicity as the preceding.

6. The ordinary theory regards the regulator as determining the pressure in the cylinder. And yet in that calculation it takes no account of the variations of the regulator.

Ours regards the regulator as fixing the pressure in the boiler and not in the cylinder. It introduces the effects of the regulator into the formulæ.

7. The ordinary theory is but an approximation more or less exact.

Ours, on the contrary, which will be seen still more developed, is a method completely analytic in all its parts.

Nothing then can be more distinct than these two methods; and as, not only since the year 1835, when we first laid down these principles in our *Treatise on Locomotive Engines*, but even as late as December, 1837, the authors who have treated these questions, whether in their writings or in their public lectures, have employed the method of coefficients, we think that the recapitulation we have just made sufficiently establishes that their conception of these questions is altogether different from our own.

We do not then deem it necessary to insist any more on this subject, and shall now pass on to the complete development of the formulæ, of which we have as yet given but a general outline.

CHAPTER II.

OF THE LAWS WHICH REGULATE THE MECHANICAL ACTION OF THE STEAM.

Section I.—Relation between the temperature and the pressure of the steam in contact with the liquid.

Before entering upon considerations which have for their basis the effects of the steam, it may be necessary to lay down in a few words, some of the laws according to which the mechanical action of the steam is determined or modified.

In the calculation of steam engines it is requisite to consider four things in the steam.

Its *pressure*, which is also called tension or elastic force, and which is the pressure it exercises on every unit of the surface of the vessel that contains it.

Its *temperature*, which is the number of degrees marked by a thermometer immerged in it.

Its *density*, which is the weight of a unit of its volume.

And its *relative volume*, which is the volume of a given weight of steam compared to the volume of the same weight of water, or, in other words, to the volume of the water that has served to produce it. We deem it necessary to add here the word *relative*, in order to avoid the confusion which would otherwise arise continually between the absolute volume filled by the steam, which may depend on the capacity of the vessel that contains it, and the relative volume which is the inverse of the density. Thus, for instance, steam generated under the pressure of the atmosphere may fill a vessel of any size, but its relative volume will always be 1700 times that of water.

When the volumes occupied by the same weight of two different steams are compared together, it is evidently a comparison of what we call the relative volumes of those two steams. For, the two steams compared having the same weight, correspond to the same volume of water evaporated. But the relative volume of the steam is the quotient of the absolute volume of the steam by the corresponding volume of water. Therefore, it follows that the ratio of the relative volumes of the two steams is the same as the ratio of their absolute volumes; and this proposition must be kept in mind for what will follow hereafter.

The steam may be considered at the moment of its generation in the

boiler, when still in contact with the liquid from which it emanates, or else as being separated from that liquid.

When the steam, after having been formed in a boiler, remains in contact with the generating water, it is observed that the same temperature corresponds invariably to the same *pressure*, and *vice versa*. It is impossible then to increase its temperature, without its pressure and density increasing spontaneously at the same time. In this state the steam is therefore at its *maximum density and pressure for its temperature*, and then a constant connexion visibly exists between the temperature and the pressure.

If on the contrary the steam be separated from the water that generated it, and that the temperature be then augmented, the state of maximum density will cease, since there will be no more water to furnish the surplus of steam, or increase of density, corresponding to the increase of temperature. That invariable connexion above mentioned, between the temperature and the pressure, will then no longer exist, and, by accessory means, the one may at pleasure be augmented or diminished, without any necessity of a concomitant variation taking place in the other, as it happens in the case of the maximum density.

It is necessary then to distinguish between these two states of the steam.

One of the most important laws on the properties of steam, is that which serves to determine the elastic force of the steam in contact with the liquid, when the temperature under which it is generated is known; or, reciprocally, to determine that temperature when the elastic force is known. Not only this inquiry is of a direct utility, but we shall see in the sequel, that it serves equally to determine the density or relative volume of the steam formed under a given pressure, a point of knowledge indispensable in the calculation of steam-engines.

Experiments on this subject had long been taken in hand, and they were very numerous for steam formed under pressures less than that of the atmosphere; but for high temperatures, the experiments extended but to pressures of four or five atmospheres. Some few only went as far as eight, and that without completing the scale in the interval. The extreme difficulty of researches of this kind, if made with proper attention, the heavy expenses they occasion, and the danger attending them, had prevented the experiments from being carried farther. But to the Academy of Sciences of the Institute of France we are indebted for a complete table on this subject. The academy confided the conduct of these delicate experiments to two distinguished scientific men, Messrs. Arago and Dulong, who evinced in them every nicety that a perfect knowledge of the laws of natural philosophy could suggest, to avoid the ordinary causes of error. Never were researches of this kind conducted on so vast a scale, nor with more accuracy. The pressure of the steam was measured by effective columns of mercury contained in tubes of crystal glass, which together extended to the height of 87 feet English. The instruments were constructed by the most skilful makers, and no expense was spared.* Therefore the greatest degree of confidence is to be attached to their results.

These beautiful experiments furnish a series of observations, from the pressure of 1 atmosphere to that of 24. To form however a table extending beyond this limit, Messrs. Dulong and Arago have sought to deduce from their observations a formula which might represent temperatures for still higher pressures without any noticeable error. They have in fact attained

* Vide Exposé des recherches faites par ordre de l'Académie des Sciences, pour determiner les forces élastiques de la vapeur d'eau à de hautes températures. *Memoires de l'Academie des Sciences*, Tome X.; *Annales de Chimie et de Physique*, Tome XLIII. 1830.

that end, by means of a formula which we shall presently report, and whose accord with experience is such, for all that part of the scale above four atmospheres, as to give room to think that, on being applied to pressures up to 50 atmospheres, the error in temperature would not in any case exceed 1 degree of the centigrade thermometer or 1·8 degree of Fahrenheit. They were enabled then, as well from the result of their observations as by means of that formula, to compose a table of temperatures of steam up to 50 atmospheres of pressure, with the certainty of committing no error worthy of note.

Though the formula of Messrs. Arago and Dulong may be applied to pressures comprised between 1 and 4 atmospheres, with an approximation that would suffice for most of the exigencies in the arts, they did not indicate the use of it for that interval, because in that part of the scale, other formulæ already known accord more exactly with the results of observation, and ought, in consequence, to be preferred. Among those formulæ, that originally proposed by Tredgold, and afterwards modified by his translator, Mr. Mellet, gave the most exact results; and no inconvenience arises from the use of it, when it is required merely to compose a table by intervals of half atmospheres. But as, for the more commodious use of the formulæ which we have to propose in this work, we shall want to establish a table by intervals of pounds per square inch; we deem it better to employ a formula which we shall give with the others presently, and which, approaching as near as that of Tredgold to the results of direct observation, in the points furnished by experiment, has moreover the advantage of coinciding exactly at 4 or 4½ atmospheres with the formula of Messrs. Dulong and Arago, which is to form the continuation of it.*

These formulæ, as well as other similar ones, have the inconvenience of suiting only a limited part of the scale of temperatures. That of Tredgold modified, as well as that which we propose to substitute for it, represent very closely the observations for the interval between 1 and 4 atmospheres; but below that point they are incorrect, and above it they are inferior in point of accuracy to that of Messrs. Dulong and Arago.

The latter accords remarkably with the facts, from 4 atmospheres to 24. In this interval its greatest difference with observation is ·4 degree of the centigrade thermometer or ·7 of Fahrenheit, and nearly all the other differences are only ·1 degree centigrade or ·18 Fahrenheit; but, as we have already said, it begins to deviate from the observation below 4 atmospheres.

Finally, among the formulæ proposed by different authors on the same

* In fact, comparing, in French measure, the two formulæ with the observation, we find the following results, as it will be easy to verify hereafter.

Elastic force in atmospheres.	Observed temperature	Temperature given by Tredgold's form. modified by Mellet.	Temperature given by the proposed formula.	Temperature given by the form. of Messrs. Arago and Dulong.
1	100·	99·96	100	"
2·14	123·7	123·54	123·34	"
2·8705	133·3	133·54	133·17	"
4·	"	145·43	144·88	"
4·5735	149·7	150·39	149·79	149·77

It appears that the formula which we propose differs from the observed temperatures nearly as much as that of Tredgold modified; but as the difference from the observation is on the *minus* side instead of the *plus*, there results a coincidence at 4½ atmospheres with that of Messrs. Arago and Dulong.

subject, that of Southern is very suitable to steam formed under pressures inferior to that of one atmosphere; it deviates then from the truth only in very low pressures, as appears from the experiments of that engineer. But for pressures superior to 1 atmosphere it ceases to have the same accuracy: from 1 to 4 atmospheres it gives more error than that of Tredgold modified, and above 4 atmospheres the error rises rapidly to 1 and 1·5 degree of the centigrade thermometer, or 1·8 and 2·6 degrees of Fahrenheit; so that the formula of Messrs. Arago and Dulong, which is, besides, of more easy calculation, becomes then far preferable to it.

No one then of these formulæ suits the whole series of the scale of temperatures, and to hold exclusively to any one of them would be knowingly to introduce errors into the tables. As moreover, the true *theoretic* law which connects the pressures with the temperatures is unknown, and that these formulæ are formulas of interpolation, established solely from their coincidence with the facts, and used merely to fill up the intervals of the experiments, according to what is wanted for the regular division of the tables, the only means of making use of them is to apply each respectively to that portion of the series which it suits. Then, from the comparison of their results with experience, one may rest assured that the error on the temperature will in no point exceed seven-tenths of a degree of Fahrenheit, or four-tenths of a degree of the centigrade thermometer. This was the means employed before us, and we shall adopt it in the formation of the tables we are about to present.

The formulæ, which will serve to compose these tables, are then the following, which we report here, not in their original terms but transformed, for greater convenience, into the measures usual in practice; that is, expressing the pressure p in pounds per square inch or in kilograms per square centimetre, and the temperature t, in degrees of Fahrenheit's or of the centigrade thermometer, reckoned in the ordinary manner.

Southern's formula, suitable to pressures less than that of the atmosphere (French measures):

$$p = \cdot 0034542 + \left(\frac{46\cdot 278 + t}{145\cdot 360}\right)^{5\cdot 13},$$

$$t = 145\cdot 360 \sqrt[5\cdot 13]{p - \cdot 0034542} - 46\cdot 278.$$

Tredgold's formula modified by Mr. Mellet, suitable to pressures of 1 to 4 atmospheres (French measures):

$$p = \left(\frac{75 + t}{174}\right)^{6},$$

$$t = 174 \sqrt[6]{p} - 75.$$

Formula suitable, like the preceding, to pressures from 1 to 4 atmospheres (French measures):

$$p = \left(\frac{72\cdot 67 + t}{171\cdot 72}\right)^{6},$$

$$t = 171\cdot 72 \sqrt[6]{p} - 72\cdot 67.$$

Formula of Messrs. Dulong and Arago, suitable to pressures from 4 to 50 atmospheres (French measures):

$$p = (\cdot 28658 + \cdot 0072003\, t)^{5},$$

$$t = 138\cdot 883 \sqrt[5]{p} - 39\cdot 802.$$

Southern's formula, suitable to pressures less than that of the atmosphere (English measures):

$$p = \cdot 04948 + \left(\frac{51\cdot 3 + t}{155\cdot 7256}\right)^{5\cdot 13},$$

$$t = 155\cdot 7256 \sqrt[5\cdot 13]{p - \cdot 04948} - 51\cdot 3.$$

Tredgold's formula modified by Mr. Mellet, suitable to pressures from 1 to 4 atmospheres (English measures):

$$p = \left(\frac{103 + t}{201\cdot 18}\right)^{6},$$

$$t = 201\cdot 18 \sqrt[6]{p} - 103.$$

Formula suitable, like the preceding, to pressures from 1 to 4 atmospheres (English measures):

$$p = \left(\frac{98\cdot 806 + t}{198\cdot 562}\right)^{6},$$

$$t = 198\cdot 562 \sqrt[6]{p} - 98\cdot 806.$$

Formula of Messrs. Dulong and Arago, suitable to pressures from 4 to 50 atmospheres (English measures):

$$p = (\cdot 26793 + \cdot 0067585\, t)^{5},$$

$$t = 147\cdot 961 \sqrt[5]{p} - 39\cdot 644.$$

Besides the formulæ which we have just reported, there exists another proposed by Mr. Biot, which, compared by that illustrious natural philosopher to the above-mentioned experiments on high pressures, to those of Taylor on pressures approaching nearer to 100 degrees centigrade. and to a numerous series of manuscript observations made by Mr. Gay-Lussac, from 100° to —20 degrees centigrade, reproduces the results observed, with very slight accidental deviations, such as the experiments themselves are liable to. This formula, which has consequently the advantage over the preceding, of being applicable to all points of the scale, is the following:—

$$\log p = a - a_1\, b_1{}^{20 \times t} - a_2\, b_2{}^{20 \times t}.$$

Log p is the tabulary logarithm of the pressure expressed in millimetres of mercury at 0° centigrade; t is the centesimal temperature counted on the air thermometer, and the quantities a, a_1, a_2, b_1, b_2, are constant quantities which have the following values:

$$\begin{aligned} a &= 5\cdot 96131330259, \\ \log a_1 &= \bar{1}\cdot 82340688193, \\ \log b_1 &= -\cdot 01309734295, \\ \log a_2 &= \cdot 74110951837, \\ \log b_2 &= -\cdot 00212510583. \end{aligned}$$

This formula cannot fail to be extremely useful in many delicate researches on the effects of steam; but to establish, by its means, a table of the form we require, the pressure ought first to be deduced from it for each degree of the air thermometer; then these degrees ought to be afterwards changed into degrees of the mercury thermometer; and as this would not givet he temperatures corresponding to given pressures, by regular intervals, a subsequent interpolation would be still necessary to make the table in the proper disposition. These long operations induced us to give the prefer-

ence to the previously cited formulæ, for the construction of the tables which we shall shortly present.

Section II.—Relation between the relative volumes and the pressures, at equal temperature, or between the relative volumes and the temperatures, at equal pressure, in the steam separated from the liquid.

We have said that when the steam is in contact with the generating liquid, its pressure is necessarily connected with its temperature; and as the density of an elastic fluid depends only on its temperature and its pressure, it follows that the density is then always constant for a given temperature or pressure. But when the steam is separated from the liquid, that connexion between the temperature and the pressure no longer exists. The temperature of the steam may then be varied without changing its pressure, or reciprocally; and according as the one or the other of these two elements is made to vary, the density of the steam undergoes changes which have been an object of investigation among natural philosophers.

One very remarkakle law in the effect of gas and steam is that which was discovered by Mariotte or Boyle, and has since been confirmed, as far as to pressures of 27 atmospheres, by Messrs. Arago and Dulong. It consists in this, that if the volume of a given weight of gas or of steam be made to vary without changing its temperature, the elastic force of the gas will vary in the inverse ratio of the volume it is made to occupy. That is to say, if v and v' express the volumes occupied by the same weight of steam, and p and p' the pressures which maintain the steam compressed under those respective volumes, the temperature, moreover, being the same in both cases, the following analogy will exist:

$$\frac{p}{p'}=\frac{v'}{v}.$$

And therefore, μ and μ' being the *relative* volumes of the steam at the pressures p and p', we shall have

$$\frac{p}{p'}=\frac{\mu'}{\mu}.$$

According to this law, if a given weight of an elastic fluid be compressed to half its primitive volume, without changing its temperature, the elastic force of that fluid will become double. But it is plain that this effect cannot take place in the steam in contact with the liquid, because it supposes that during the change of pressure the temperature remains constant, whereas we have seen that in such state the pressure always accompanies the temperature, and *vice versa*.

Another property equally important in the appreciation of the effects of steam has been discovered by a celebrated chemist of our times, Mr. Gay-Lussac. It consists in this, that if the temperature of a given weight of an elastic fluid be made to vary, its tension being maintained at the same degree, it will receive augmentations of volume exactly proportional to the augmentations of temperature; and for each degree of the centigrade thermometer, the increase of volume will be ·00364 of the volume which the same weight of fluid occupies at the temperature zero. If the temperatures are taken from Fahrenheit's thermometer, each augmentation of 1 degree in the temperature will produce an increase of ·00202 of the volume occupied by the fluid at the temperature of 32°

If then we call V the volume of the given weight of the elastic fluid, under any pressure, and at the temperature of 32 degrees of Fahrenheit, the

volume it will occupy under the same pressure, and at the temperature t of Fahrenheit will be

$$v = V + V \times \cdot 00202\,(t - 32).$$

It follows that, between the volumes v and v' occupied by the same weight of steam, at the same pressure and under the respective temperatures t and t', there will be the following analogy:

$$\frac{v}{v'} = \frac{1 + \cdot 00202\,(t - 32)}{1 + \cdot 00202\,(t' - 32)},$$

which will also be true, when we replace the ratio of the two absolute volumes v and v', by the ratio of the *relative* volumes μ and μ' of the steam.

This law, supposing that the temperature of the steam changes, without the pressure undergoing any change, obviously cannot apply to the effects produced in steam in contact with the liquid, since in those the pressure changes necessarily and spontaneously with the temperature.

(To be continued.)

The Patent Rotative Disc Engine.—Mr. Whishaw having been requested to examine and report on the principle of construction of the rotative disc engine, and to institute a comparison between it and those of the reciprocating kind, devoted a week to the purpose, and examined six different engines, the whole of which were represented by the parties at whose works they are in use, to have performed their duties most satisfactorily. One of these engines (Mr Whishaw observes) has been working for fifteen months, and has only required during this period the expenditure of three shillings for repairs. Mr. Whishaw continues:—"The advantages to be derived from a rotative engine of simple construction, yet producing a mechanical effect, equal to one on the reciprocating principal, at much less original cost, and with less expenditure of fuel, must be obvious to every one. Such a machine has long been a desideratum amongst engineers. The attempts which have hitherto been made to accomplish this desirable object, so far as my knowledge extends, have failed, either from the motion of the various parts of the machine being such as to produce so great an amount of friction, and consequently, of rapid destruction; or from the engines requiring a greater supply of steam to effect a given amount of work. In my examination, therefore, of this invention, I have particularly directed my attention to these two important points. As regards the first, I find the moving parts of this engine are so few in number, and their motion so uniform and regular, that the amount of friction must be very materially reduced; the wear, therefore, of these moving parts, and their liability to derangement, will be reduced in a proportionate degree. This opinion is fully borne out by the examination I have made of several engines, which have been in operation for a considerable time; some of these were taken to pieces in my presence, for the purpose of ascertaining the wear of the moving parts, the amount of which appeared so small as to be inappreciable. With respect to the second, viz:—the quantity of steam required to perform a certain amount of work—I have made several trials with an engine of this construction at the works of the British Alkali company, near Broomsgrove, which is applied to a great variety of work, but as a considerable portion of the duty performed consists of pumping, I was thus enabled to make such a comparison between the different portions of the work, as to obtain an accurate indication of the whole duty performed. The result of these trials is, that the work done by this twenty-four inch disc engine, working with steam at 29 lbs. pressure, is equal to twenty horses' power, after making ample allowance for friction; and the consumption of fuel (common Staffordshire coal) is equal to *two hundred weight*

per hour, or rather more than *eleven pounds* per horse per hour.—*Civ. Eng. and Arc. Jour.*

For the American Railroad Journal, and Mechanics' Magazine.

METEOROLOGICAL RECORD FOR THE MONTHS OF JULY and AUGUST, 1839.

Kept on Red River, below Alexandria, La., (*Lat.* 31.10 *N.*, *Long.*, 91.59 *W.*)

1839	Thermometer.					Remarks.
July.	Morn.	Noon.	Night.	Wind.	Weath.	
1	74	84	80	calm	clear	
2	74	86	79	NE	..	
3	76	88	82	SE	..	
4	76	90	83	calm	..	evening cloudy
5	77	91	83	SE	..	evening cloudy and distant thunder
6	75	92	83	calm	..	
7	78	80	81	..	cloudy	rain heavy thunder in the morning eve. clear
8	76	83	83	..	clear	light showers in the morning clear day
9	77	88	83	..	..	
10	78	88	82	SW	..	evening cloudy light shower heavy thunder
11	78	79	79	..	..	morning and forenoon distant heavy thunder
12	76	80	78	..	cloudy	all day rain at night [no rain cloudy all day
13	76	82	79	..	..	" light showers
14	78	76	74	NW	..	very heavy rain forenoon even. clear and calm
15	72	81	74	calm	clear	
16	70	84	78	..	..	
17	71	83	78	..	..	
18	74	79	72	NW	cloudy	rain all day
19	72	80	76	..	..	no rain
20	72	82	72	S	clear	morning rain in the evening
21	71	88	78	W	..	all day
22	77	87	82	calm	cloudy	morning clear day
23	75	87	83	..	clear	
24	76	88	84	..	..	
25	76	90	86	..	..	
26	77	91	80	SW	..	evening cloudy
27	75	90	80	..	..	" " heavy distant thunder
28	77	91	84	W	..	
29	78	89	85	calm	..	
30	80	91	85	..	..	
31	80	91	87	NE	..	
	70	86	78	....	....	mean temp. of the month 78.1.
Aug.						
1	78	91	80	S	clear	
2	76	90	80	calm	..	evening cloudy
3	75	89	80	SW	..	shower afternoon
4	78	89	78	..	..	thunder shower in the evening
5	76	89	86	calm	..	
6	80	90	88	SW	..	
7	81	92	85	calm	..	showers at night from north west
8	81	88	83	W	..	
9	80	88	81	NW	..	cloudy evening
10	75	90	82	calm	..	
11	76	89	81	..	cloudy	
12	72	86	84	..	..	
13	72	87	80	..	..	cloudy all day
14	78	84	80	..	clear	
15	74	86	80	..	..	
16	74	85	81	W	..	
17	72	84	79	calm	..	evening cloudy, showers from north east
18	73	83	80	..	..	light showers at night
19	75	80	74	..	..	
20	76	90	80	..	..	
21	70	90	80	..	..	
22	74	90	85	..	..	
23	74	91	80	..	..	
24	78	89	80	..	..	
25	79	83	70	W	..	showers afternoon
26	78	84	79	..	..	
27	74	88	83	S	..	
28	75	85	80	W	..	showers at daybreak
29	70	84	78	NW	..	
30	69	85	76	..	..	
31	66	85	75	N	..	
	75	87	80	....	....	mean temp. of the month 81.